American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Suspected Upper Extremity Deep Vein Thrombosis**

Variant 1: **Previous catheter placement.**

Radiologic Procedure	Rating	Comments	RRL*
US upper extremity with Doppler	8	Best first approach for direct evaluation of arm veins.	None
X-ray chest	8	Usually ordered as the first test to supply information about the catheter and the chest. Also serves as a baseline.	Min
INV venography upper extremity	8	If non-invasive studies are inconclusive or patient is a candidate for interventional therapy.	Min
MRI upper extremity and chest (including MRV)	7	Useful for central venous obstruction.	None
CT upper extremity and chest with contrast	5	Useful as problem solving tool in certain situations and for central venous obstruction.	Med
NUC radionuclide venography upper extremity	2		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: **No previous catheter placement.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	Usually ordered as the first test to supply information about the chest and to serve as baseline.	Min
US upper extremity with Doppler	8	Best first test for visualization of arm veins.	None
MRI upper extremity and chest (including MRV)	7	Useful for central venous obstruction.	None
INV venography upper extremity and chest	7	If non-invasive studies are inconclusive or patient is a candidate for interventional therapy.	IP
CT upper extremity and chest with contrast	5	Useful as problem solving tool in certain situations and for central venous obstruction.	Med
NUC radionuclide venography upper extremity	4	May be valuable, but has been supplanted with Duplex and cross-sectional imaging.	Med
X-ray cervical spine	3		Low
X-ray shoulder	1		Min
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

SUSPECTED UPPER EXTREMITY DEEP VEIN THROMBOSIS

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Summary of Literature Review

Upper extremity venous thrombosis often presents as unilateral arm swelling. The differential diagnosis includes lymphatic obstruction, a mass lesion compressing the central veins and causing a functional venous obstruction, a localized mass lesion in the arm, or an infection causing edema. Bilateral upper extremity swelling may be due to right-sided heart failure and is typically associated with generalized swelling, whereas central vein obstruction can cause upper extremity and facial swelling.

The following recommendations are made with the understanding that venous disease, specifically venous thrombosis, is the primary diagnosis to be excluded or confirmed in a patient presenting with unilateral upper limb swelling.

Upper Extremity Deep Vein Thrombosis

Upper extremity deep vein thrombosis (DVT) can be associated with indwelling catheters, be idiopathic or post-traumatic, or be secondary to "effort thrombosis."

Upper extremity DVT is commonly associated with the presence of indwelling central venous catheters. The presence of the catheter, a foreign body, increases the likelihood of venous thrombosis by altering flow, causing damage to the endothelial lining of the vein, and serving as a site for platelet adherence. The increased utilization of chronically indwelling catheters for hemodialysis, chemotherapy, or parenteral nutrition, often in a population that already has additional risk factors for venous thrombosis, has increased the incidence of upper extremity DVT from the low incidence rates reported in the late 1940s. As is the case with lower extremity DVT, the likelihood of arm thrombophlebitis increases with the presence of risk factors, such as age, previous thrombophlebitis, and postoperative state. The likelihood of upper extremity thrombosis also increases in the presence of congestive heart failure.

The location of the venous thrombosis is strongly linked to the clinical presentation. For example, head, neck, and bilateral swelling are likely due to a central process in the mediastinum or to involvement of both subclavian and brachiocephalic systems. Superficial thrombophlebitis is associated with local pain, induration, and, often, a palpable cord. It is rarely, if ever, associated with diffuse arm swelling. Unilateral swelling indicates an obstructive process at the level of the brachiocephalic, subclavian, and, occasionally, axillary veins. DVT limited to the brachial veins and even the axillary veins need not be associated with swelling. Isolated jugular vein thrombosis is asymptomatic and rarely causes neck swelling.

Upper Extremity Swelling, Lymphatic Obstruction

The mechanism responsible for arm swelling may be obstruction of previously functioning lymphatics or the absence of sufficient lymphatic channels to ensure effective drainage. Lymphatic obstruction can be seen with overwhelming infection such as cellulitis or can be secondary to invasion of the lymphatics by tumor. Absence of the lymphatics can be congenital or secondary to surgery, such as following a radical mastectomy.

Differentiating Causes of Arm Swelling

The general approach to evaluation of a swollen upper extremity is that the diagnosis of venous thrombosis must be excluded. The reason is simple—the swelling, as a clinical sign, can respond to treatment with anticoagulation and might even be amenable to more aggressive interventions such as thrombolysis. Once the diagnosis of DVT is excluded, the possibility of lymphatic obstruction may need to be confirmed by objective means. Different imaging techniques that can be used to achieve the diagnosis include noninvasive tests such as plethysmography, radionuclide tracers for confirming venous obstruction or to image thrombus directly, ultrasound (US), magnetic resonance imaging (MRI), computed tomography (CT) and finally phlebography.

In patients with indwelling central venous catheters, phlebography, Doppler US and magnetic resonance angiography (MRA) have been used to document the presence of non-obstructive (asymptomatic) thrombi. Phlebography remains the best diagnostic modality for establishing the presence of venous stenosis and obstruction in the asymptomatic patient, while sonography can be used to visualize fibrin sheaths that form around chronically indwelling catheters.

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Chest Radiography

Because of the broad differential diagnoses of upper extremity swelling, a chest radiograph is often ordered as a first step. This might help confirm the presence of a mass lesion responsible for central venous obstruction or help confirm the presence and location of a venous catheter or even the presence of pacing or defibrillator electrodes. Rare entities that might be associated with extrinsic compression syndromes, such as a cervical rib, would also be detected.

Plethysmography

Venous plethysmography measures blood volume changes in the arm. Blood volume is typically reduced, unless the patient has a very proximal obstruction. Venous emptying is typically reduced. The use of this noninvasive test has, in essence, been supplanted by venous US.

Radionuclide Imaging, Flow Studies

Radionuclide studies have often served as the minimally invasive test capable of confirming upper extremity venous obstruction. This modality has been used chiefly for diagnosing superior vena cava (SVC) syndrome. The diagnostic criteria include failure to visualize one or more of the main venous segments (axillary, subclavian, or brachiocephalic) and visualization of collateral venous channels. This diagnostic test can be used to confirm the presence of venous obstruction but not to differentiate intrinsic venous thrombosis from extrinsic compression of the vein.

Radionuclide Imaging, Labeled Red Cells (Volume Imaging)

This approach images the blood pool within the veins. Venous thrombus displaces labeled red cells in the blood and shows up as an area of decreased radioactivity on the image. Extrinsic compression of the vein can also cause an area of decreased radioactivity since local blood volume is decreased in the compressed segment. This technique has been used to image the leg veins but has not to date been studied for evaluation of upper extremity and central veins.

Radionuclide Imaging, Thrombus-Directed Agents

Thrombus-specific agents bind to the site of actively forming thrombus. Many agents have been used, from labeled fibrinogen (no longer available) to labeled antifibrin antibody. These agents are specific for thrombus. In the lower extremity, imaging is normally done hours to days after the injection of the compound in order to decrease the background level of radioactivity. As an example, labeled antifibrin antibody is best imaged 24 hours after injection, although early images can be taken at 6 hours if an antibody fragment is used. There are no series in the literature describing the use of this technique for upper extremity swelling.

Venography (Phlebography)

This is the "gold standard" examination for evaluating the upper extremity veins. The examination carries the risks associated with the injection of an iodinated contrast agent. The nonionic and low osmolality agents offer the advantage of better patient tolerance and less discomfort. The risks of minor adverse events are reduced compared to standard contrast agents. Based on findings from lower extremity phlebography, the incidence of phlebitis following the injection of non-ionic/low osmolality agents is lower than for the injection of ionic, high osmolality agents. Direct evidence of venous thrombus is based on the visualization of a filling defect in the vein or of a "cut-off." The presence of collateral channels is supportive of a positive diagnosis. There are no large autopsy validations of phlebography but instead a series of correlative cases. Contrast phlebography has been implicitly accepted as a "gold standard" based on its' diagnostic performance for lower extremity DVT.

Venous Ultrasound

This is a relatively inexpensive and atraumatic examination. It can be used to exclude the presence of a significant DVT or of a proximal venous obstruction. Diagnostic criteria include loss of compressibility, altered blood flow patterns, or visualization of echogenic material in the vein. Compressibility of the vein is evaluated by applying pressure to the soft tissues overlying the vein. Loss of compressibility is consistent with acute DVT but can also occur in the presence of chronic venous thrombosis. This maneuver is typically used for the more superficial veins (jugular, lateral subclavian, axillary, basilic, cephalic, and brachial). A full examination also includes the evaluation of the Doppler velocity profiles obtained from moving blood in the major veins. Alterations in Doppler velocity profiles due to cardiac pulsatility are reliable indicators of central venous obstruction. In addition, respiratory maneuvers such as rapid inspiration or "sniffing" should cause the walls of the subclavian veins to co-apt. Impairment of this collapse (which is related to rapid venous emptying) also indicates a central obstructive process. However, a central thrombus will cause the same alterations in blood flow as a mass encasing or compressing the central (superior vena cava, brachiocephalic) veins.

Color flow imaging can be used to image the blood flow patterns within the vein and is useful in evaluating venous segments where compression maneuvers cannot be applied (eg, central subclavian vein). Gray scale imaging can be used to judge the echogenic structure of a thrombus. Echogenic thrombi can be positively identified, while hypoechoic thrombi may be missed. Adjunctive use of color flow images can help in confirming the presence or absence of hypoechoic thrombus. Correlative studies between US and phlebography, show diagnostic accuracies above 80%.

Magnetic Resonance Imaging

There are three imaging approaches available utilizing MRI sequences. With direct imaging, a thrombus shows up as a focal mass in the vein lumen. This approach is very useful for identifying chronic thrombi since the associated thickened vein wall is readily seen on T1- and T2-weighted images. A central thrombus may be suspected when the vein is distended and contains signals of different intensity than those of the non-involved vein. Artifacts due to signal rephasing may be difficult to distinguish from partly obstructive thrombus. With time-of-flight magnetic resonance venography, a flow-sensitive sequence is used to image blood flow in the vein lumen. A thrombus shows up as areas of decreased signal intensity.

Magnetic resonance techniques permit imaging of the more central veins. Contrast enhanced MRI with gadolinium compounds has become the favored approach for imaging the upper extremity veins. Imaging is done during the venous phase following a bolus injection of the gadolinium compound. The typical zone of coverage includes the axillary veins to the superior vena cava on one image. Despite wide clinical acceptance, there are few correlative studies validating the use of MRI of the upper extremity veins against the "gold standard", contrast phlebography.

Computed Tomography

CT can be used to determine the presence of centrally located thrombi within the jugular veins, the brachiocephalic veins, and the superior vena cava. The presence of an extrinsic process causing obstruction of the venous channels can also be determined. Rapid imaging sequences during injection of contrast material are typically used to evaluate the pulmonary arteries for suspected pulmonary embolism. Delayed imaging at 2 to 3 minutes can permit evaluation of the central veins. No large series have looked at the diagnostic accuracy of this technique diagnosing upper extremity venous thrombosis, although extensive experience is accumulating with lower extremity venous thrombosis.

Contrast Lymphography

Lipid-soluble contrast agents are injected in the subcutaneous tissues of the hand. The number and course of the lymphatic channels can then be imaged. This technique is rarely used. It may be useful in evaluating patients with previous surgery or radiation therapy at the sites of draining lymph nodes, such as the axillary nodes.

Lymphoscintigraphy

A labeled colloid preparation of small diameter particles (Tc-99m antimony sulfur colloid; Tc-99m human serum albumin micro-colloid) can also be injected between the digits. The transit of the radiolabeled compound can then be traced through the lymphatic channels. Areas of obstruction show up as zones with no uptake contiguous to lymphatic channels. Lymph node uptake is absent, or the number of lymph nodes is decreased. This imaging technique displays the functional state of the lymphatics but does not offer much anatomic information.

Summary

Despite the availability of noninvasive imaging techniques, contrast phlebography remains the most useful, best documented diagnostic test for suspected upper extremity acute venous thrombosis. In the lower extremity, contrast venography is rarely needed since noninvasive imaging modalities have sufficient diagnostic accuracy. In the upper extremity, imaging with US has slightly lower accuracy than it has in the lower extremity. Imaging with gadolinium contrast enhanced MRI is routinely used to evaluate the status of the central veins. Unfortunately, despite widespread clinical use, there are few validation studies in comparison to contrast venography. Delayed computed tomographic venography can often be used to confirm or exclude more central vein venous thrombi. As in the case of magnetic resonance venography, there are few correlative studies justifying this approach. Contrast venography may be needed whenever other noninvasive strategies fail to adequately image the upper extremity veins.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations	
Relative Radiation Level*	**Effective Dose Estimate Range**
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv
*RRL assignments are not included for some examinations. The RRL assignments for the IP (in progress) exams will be available in future releases.	

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